INTRODUCTION

EnSight's ability to handle large, transient datasets has led to its use in the production of many video animations of engineering and scientific data. EnSight uses a *keyframe animation* system. A keyframe is a set of viewing parameters that specify a particular view of the scene in the Graphics Window. The view may be notable because of what is visible, or because the view represents the transition point from one scene to another. Once a set of keyframes has been selected, EnSight can automatically generate frames to interpolate the viewing parameters between keyframes for a smooth animation.

The changes to viewing parameters between keyframes are not limited to simple rotations, translations, or zoom operations. You can also use EnSight's **frames** capability to move parts independently, *e.g.* to animate an exploded view of a complex assembly. You can also animate the **global look-from and look-at points** for "fly-by" style animations.

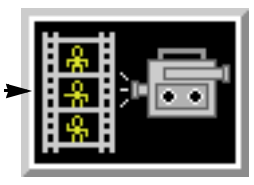
While refining your animation, you can display it directly in the Graphics Window. When complete, you can specify the output resolution (*e.g.* for NTSC or PAL video) and set the recording device (*e.g.* to a disk file).

Although the production of adequate animation is easy, good animation takes experience. A sequence that looks good on your high resolution workstation screen may look less than acceptable when transferred to VHS videotape. An object rotating in ten degree increments may be an appropriate speed for your workstation graphics. At thirty frames per second, however, the rotation will complete in just over a second – too fast for normal viewing. See the **Other Notes** section for some additional hints and tips.

BASIC OPERATION

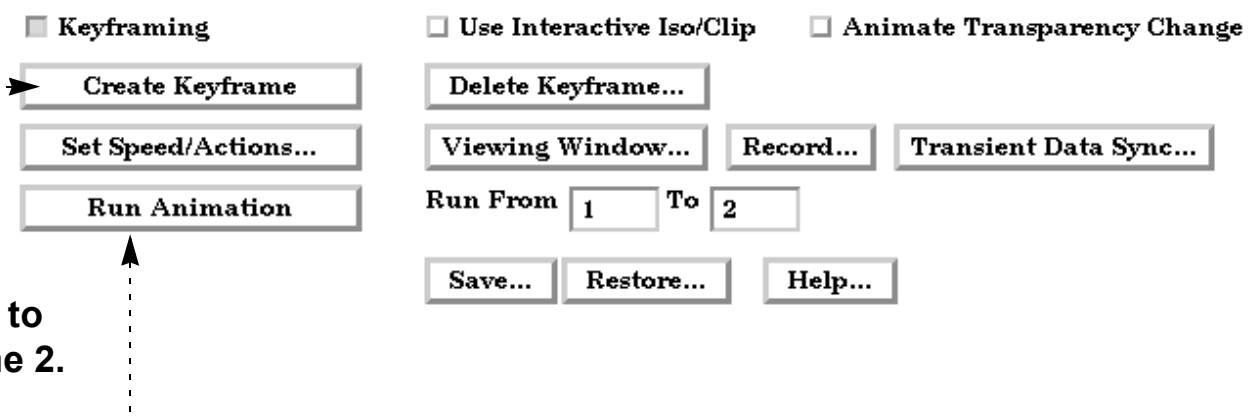
All keyframe animation functions are controlled through the Keyframe Quick Interaction area:

1. **Click the Keyframe Animation icon in the Feature Icon bar.**



2. **Set all viewing parameters to the desired location for keyframe 1.**

3. **Click Create Keyframe to save the first keyframe.**



Note that the Keyframing toggle is automatically switched on when you begin saving keyframes.

4. **Change the viewing parameters to the desired location for keyframe 2.**

5. **Click Create Keyframe to save keyframe 2.**

You can play your animation at any time to check your results. The animation will play the keyframe range specified in the Run From/To fields.

6. **Click Run Animation to play the animation.**

7. **Continue to change viewing parameters and click Create Keyframe until you have saved all desired keyframes.**

Important Notes!

You can abort a running animation by moving the mouse into the animation display window and pressing the 'a' key.

If you toggle-off the Keyframing button, any keyframes currently defined will be deleted. If you wish to save a set of keyframes, click the Save... button.

Create a Keyframe Animation

There many ways to specify the desired transformations between keyframes. See the following articles for more information:

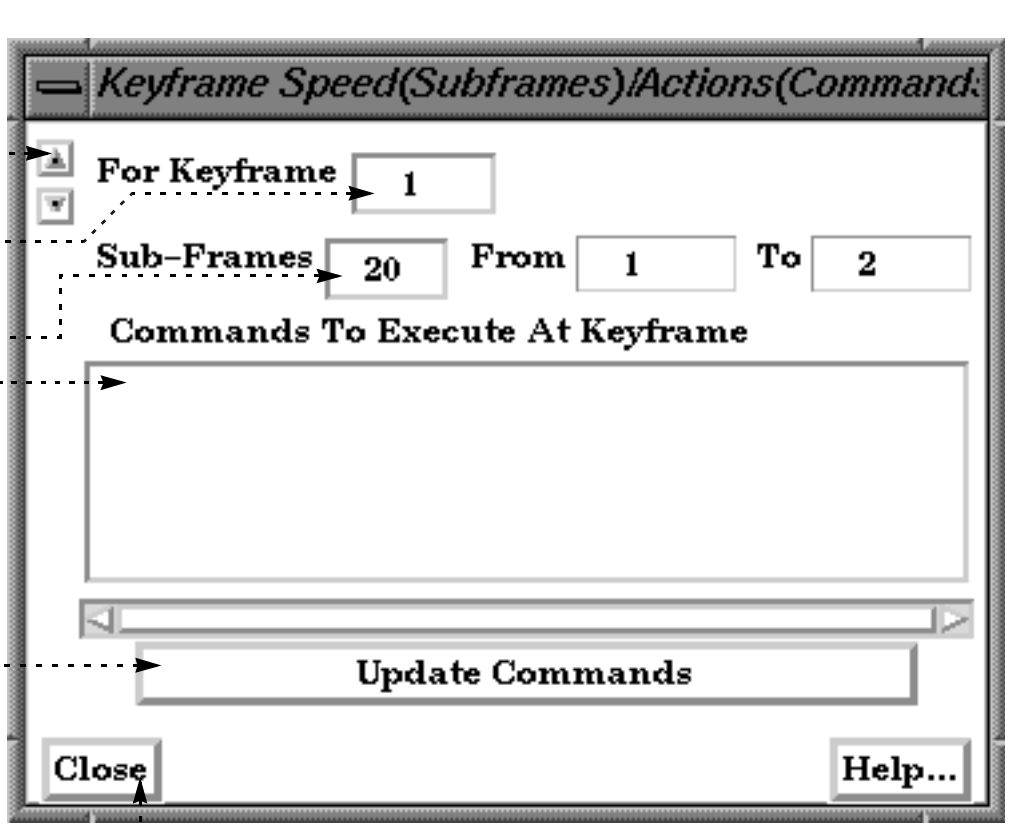
How To Rotate, Zoom, Translate, Scale
How To Create and Manipulate Frames
How To Set LookFrom/LookAt
How To Define and Change Viewports

The following sections provide details on the animation control dialogs opened from the Keyframing Quick Interaction area.

Set Speed/Actions...

The Speed/Actions dialog allows you to set the number of sub-frames between each pair of consecutive keyframes as well as specify commands to execute at keyframes:

1. **Click Set Speed/Actions in the Keyframing Quick Interaction area.**
2. **Select the desired keyframe to edit: either enter the value or use the up/down buttons.**
3. **Enter the desired number of sub-frames between the keyframe selected in step 1 and the next (the default is 20).**
4. **If desired, enter EnSight commands to execute when the selected keyframe is reached. The command(s) will be executed before the frame is displayed.**
5. **If you added or changed the commands to be executed at a keyframe, click Update Commands.**
6. **Continue by selecting a new keyframe to edit and click Close when done.**



The number of sub-frames controls the speed with which objects transform between keyframes. More sub-frames yields slower motion.

You can insert any valid EnSight command to be executed at a keyframe. If your command sequence is more than a few lines, it is best to save the sequence in a file and just enter the command `play: filename`. There is a special case of executing a command at a keyframe. If you insert the command `shell: filename`, The file `filename` (which is assumed to be a UNIX executable command) will be executed *after* each sub-frame and each surrounding keyframe. In addition, if you are saving animation frames to disk files, the name of the image file just written is passed to the executable as the first argument. This capability can be used to postprocess the image files, for example to resize and re-sample an image or copy it to a different location. If this capability is used, the `shell: filename` command must be the only command specified.

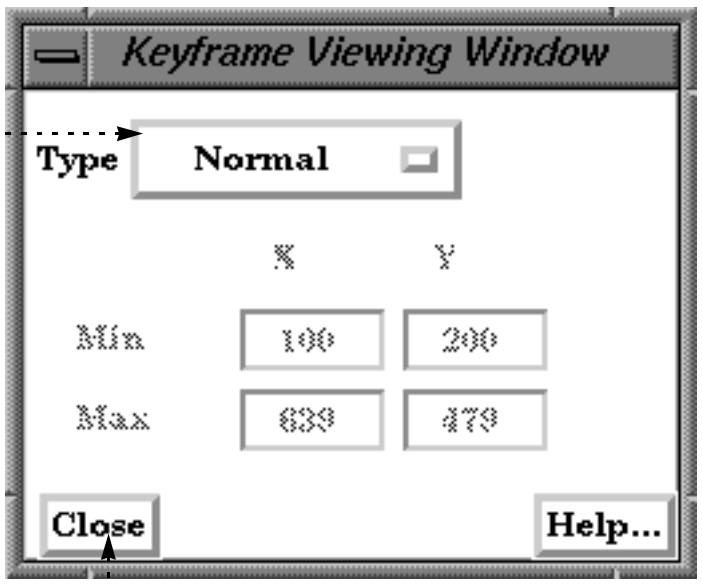
Create a Keyframe Animation

Viewing Window...

The Keyframe Viewing Window dialog allows you to set the size and location of the animation display window:

1. **Click Viewing Window... in the Keyframing Quick Interaction area.**

2. **Select the desired window type:**



Normal	Use the current Graphics Window (initially 794 x 659)
Full	Use the full screen with no window borders (typically 1280 x1024)
NTSC	Use NTSC video resolution (640 x 480) and position at the lower-left corner
PAL	Use PAL video resolution (720 x 576) and position at the lower-left corner
User Defined	Use the Min/Max X and Y settings

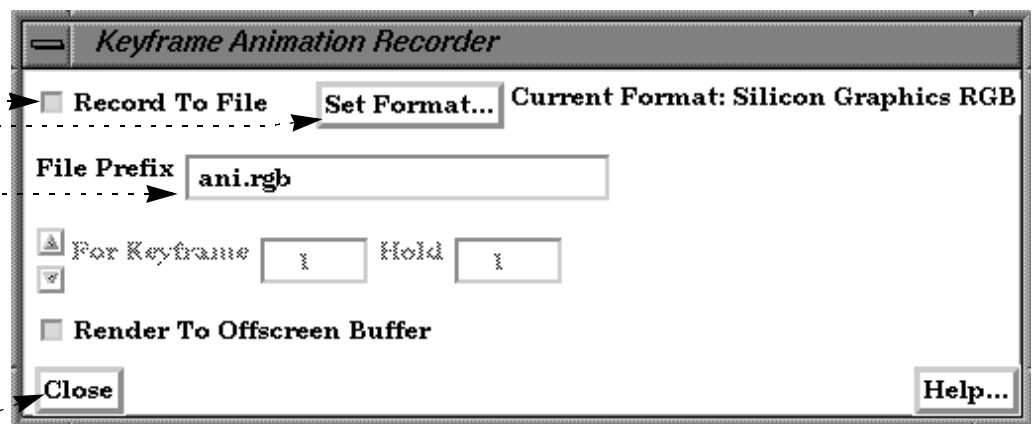
The Min setting for User Defined specifies the position of the lower-left corner of the animation window (as an offset from the lower-left corner of your monitor screen). The Max setting is the upper right corner of the animation window.

3. **Click Close.**

Record...

The Keyframe Animation Recorder dialog specifies the type of recording device:

1. **Click Record... in the Keyframing Quick Interaction area.**
2. **Toggle on Record To File.**
3. **Select the desired file format and options.(see below).**
4. **Provide the File prefix.**
5. **Click Close.**



Available recording file formats:

Apple PICT	Animation files saved as sequence of Apple PICT files.
JPEG	Animation files saved as sequence of JPEG files.
TIFF	Animation files saved as sequence of TIFF files.
PCL	Animation files saved as sequence of Page Control Language files.
PostScript	Animation files saved as sequence of PostScript files.
Silicon Graphics RGB	Animation files saved as sequence of SGI RGB files.
TARGA	Animation files saved as sequence of TARGA files.
CEI RGB with Z	Animation files saved to an RGB file. The depth (Z) values are also saved.
EnVideo	Animation files are saved to EnVideo file.
MPEG	Animation files are saved to an MPEG file.
AVI	Animation files are saved to an AVI file.

Transient Data Sync...

The Keyframe Transient Data Synchronization dialog allows you to specify how transient data is synchronized with your animation frames. By default, when transient data calculation is enabled, each time step corresponds to each frame of the animation in turn. For example, if you have 10 time steps and two keyframes, you should specify 8 sub-frames to completely display the transient sequence. You can, however, change how your simulation time steps map to animation frames.

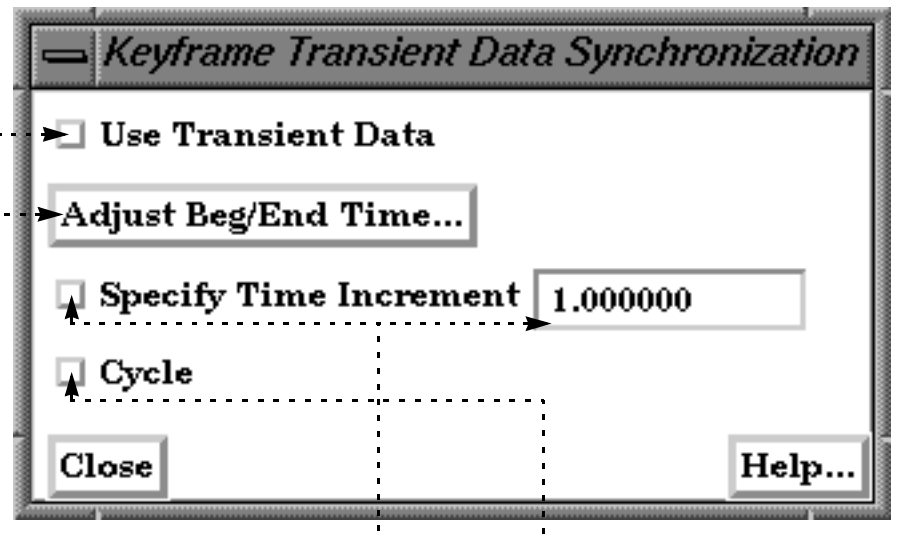
1. **Click Transient Data Sync... in the Keyframing Quick Interaction area.**

2. **Click the toggle to enable transient data calculation during the animation.**

3. **If desired, reset the current beginning and ending time. (Clicking this button will replace the Keyframe Quick Interaction area with the Solution Time Quick Interaction area. When you are done, return to the Keyframe Quick Interaction area).**

4. **Toggle on to specify a time increment different from 1.0 and enter the desired value. This value is added to the current time step to yield the next. If it is less than 1, EnSight will interpolate to yield intermediate time steps.**

5. **Toggle on to specify that the available time steps will play back in reverse order once the last time step has been reached. By default, EnSight will return to the first time step.**



Use Interactive Iso/Clip

By turning this toggle on, any clip or isosurface interactively moved during the keyframe will animate.

Animate Transparency Change

By turning this toggle on, transparency changes to parts during the definition of the keyframes will be part of the animation.

Save and Restore

A set of keyframes and related information can be saved to disk and later restored. To save keyframes:

1. Click Save... in the Keyframing Quick Interaction area.

2. Enter the desired file name in the File Selection dialog and click Okay.

To restore previously saved keyframes:

1. Click Restore... in the Keyframing Quick Interaction area.

2. Enter the desired file name in the File Selection dialog and click Okay.

Other Notes

As pointed out in the introduction to this article, high-quality animation takes time and experience. CEI has produced a great deal of animation over the years and has learned a variety of lessons. In the hope that EnSight users can avoid many of the pitfalls inherent in the process, many of these lessons and rules of thumb are presented here.

EnSight's keyframe animation methodology is borrowed from the animated film industry. In making animated films, the master animator defines how the scene will look at certain points in time (the keyframes) and then hands the work off to an "in-betweener", with instructions on how many frames to add between each pair of keyframes. The in-

betweener then draws the missing frames. EnSight's approach is similar with the user as the master animator and EnSight as the in-betweener. Some of the strengths of this approach include:

1. When keyframing is on, EnSight is not only recording the viewing parameters when you click Create Keyframe, it also records the actions taken to get from the last keyframe to the current one. This approach permits certain operations to be performed without ambiguity (such as rotating by 180 degrees or more).
2. Each Viewport can be animated independently.
3. Flipbooks can be played during an animation.
4. Animated particle traces can be played during an animation.
5. Transient data is easily synchronized with the generated frames. When the animation is run, EnSight will automatically step through time and recalculate all time-dependent entities.
6. Output can go direct to an animation controller, or raster images can be saved to disk files for later recording, manipulation, or conversion to other formats (*e.g.* MPEG or QuickTime).
7. Additional power and flexibility can be achieved since EnSight command language statements can be issued at keyframes.

The keyframe capability was designed to enable engineers and scientists to produce quality animation. As such, it lacks most of the more elaborate controls available in commercial animation packages (which typically cost 2-3 times more than EnSight). Some limitations:

1. Only transformation parameters (global, frame and camera transforms) are saved through the keyframing process. Other parameters and part attributes are not interpolated between keyframes.
2. There is no spline or acceleration control – all transformations are linear in speed and position.
3. Light sources are fixed in EnSight – they cannot move during the animation.
4. The shading and lighting model used by EnSight is fairly simplistic.

Tips for Video Recording

Animation Holds

Whenever an animation is started or stopped use a "hold" to allow your viewers to establish the visual context of the scene. A hold of 3 seconds at the beginning and 2 seconds at the end usually works well. For complex imagery, longer holds may be required. Note that a hold can typically be performed at the recording level – it is not necessary to have EnSight compute multiple frames for a hold.

Rate Control

The speed at which events occur during an animation is one of the most difficult aspects to master. Viewers become confused and disoriented if motion is too fast; too slow and your viewer may lose interest. The frame rate for NTSC (the video format used in North America) is 30 frames per second. Although there is a great deal of variation (depending on graphics hardware speed and model size), your workstation will typically have a much slower frame rate. Therefore, what appears to be good speed on your workstation may be much too fast when recorded to video at 30 frames per second.

Trial and error is one method to determine proper rates. Although you may end up doing some "line test" video recording to refine your rates, use the method described here to derive good starting values:

1. Define all the keyframes.
2. Set up the animation to play back at full screen.
3. Set up the animation to play only from the first to the second keyframe.
4. Set the number of sub-frames between keyframes 1 and 2 to be 300.
5. Select View > Bounding Box > Static Box.
6. Using a watch with a second hand, time how long it takes to play the animation. Call this time "T". We know that it will take 10 seconds to play 300 frames on video. Compute the following:

   factor = T/10.

For example, if you find T to be about 12 seconds, then factor is 1.2, which means that the rate you see on the screen is 1.2 times slower than what you will see on video.

7. Iteratively adjust the number of sub-frames between keyframe 1 and 2 (running the animation after each adjustment) until you like the rate you see on the screen.
8. Finally, adjust the number of sub-frames by the factor found in step 6. For example, if 150 sub-frames were required for a good rate of speed, then change the number of sub-frames to 150*factor to see the same rate on video.
9. Perform steps 3 through 8 for the next set of keyframes.

Transient Data

Animation is particular useful for presenting transient data. However, since both viewing parameters and time can change simultaneously, the potential for confusing viewers is very high. In general, you should never change both viewing parameters and time simultaneously. It is typically much better to use transformations in an opening scene to present the model to the viewer. The transformations should end at a vantage point suitable for viewing the transient phenomena. At that point, the time-dependent data can be displayed. If you must alter the scene during transient display, do so with great care to avoid disorienting viewers.

Note that you can animate time-dependent information without transformations by merely creating two keyframes without performing any transformations between them.

In many instances, there will not be enough time steps in the simulation to produce an animation of adequate duration. If the simulation does not involve changing geometries, EnSight can interpolate between time steps (linearly) to yield additional frames. However, keep in mind that your simulated phenomena is almost certainly not linear in nature. If you have EnSight generate more than a few interpolating frames between each actual time step, the resulting discontinuity at keyframes (from the piece-wise linear interpolation) is quite visible in the resulting video.

Frame count

The total number of frames that EnSight will produce during the animation is the sum of all sub-frames plus the number of keyframes. This is especially important to keep in mind when synchronizing transient data with animation frames.

Animated Traces

If you display animating particle traces during keyframe animation, you may have noticed that the trace animation always resets at the beginning of the keyframe animation. However, in most cases it is desirable to have the trace animation fully in progress when the animation begins. This can be accomplished by creating an additional keyframe at the beginning of the animation. Set the number of sub-frames between keyframes 1 and 2 to a value high enough to yield the desired tracer saturation. When you run the animation, set the Run From field to 2 so that the animation begins generating frames with keyframe 2. At that point, the tracer animation process will have executed once for each sub-frame between keyframes 1 and 2.

Color

The color gamut (the range of colors a device is capable of displaying) of video (especially NTSC) is significantly less than that of your workstation monitor. The result is that certain colors that look fine on your workstation cannot be reproduced on video. Fully saturated colors (especially red and blue which “bleed” across the screen) are particularly troublesome. However, it is quite easy to de-saturate your images prior to recording. There are actually three ways to do this:

1. Modify all of the colors in use to de-saturate them. For example, if a color is pure red (1., 0., 0.), change it to be a more pastel red (.85, .1, .1).

2. Modify the saturation factor in the Image Format Options. A factor of 0.85 is usually good.

3. Create your animation, then de-saturate the images using an image tool such as the one available from the San Diego Supercomputing Center (it’s free). This will only work, of course, if you are saving animation images to disk files.

Dark backgrounds work much better than light backgrounds. Black is often the best choice.

Lines

Moving single-width lines have a tendency to “crawl” on video. Use a minimum line width of 2.

Anti-aliasing

Without correction, computer-generated imagery exhibits aliasing artifacts that typically show up as jagged edges. For our purposes it is sufficient to say that aliasing results from sampling at a resolution too low to capture the "signal" represented by the underlying geometry. We can only sample our geometry at the available pixels. Since the effective number of pixels in the NTSC video signal is only one quarter the number of your workstation screen, what looks fine on your workstation may be less than acceptable on video. Although EnSight provides no direct anti-aliasing support, there are ways to mitigate this problem.

1. If you are recording images from EnSight directly to a video recorder, use a scan converter (a piece of hardware) to filter full screen images to NTSC resolution images.
2. If you are recording images to disk files, record them at full screen resolution and then use an image re-scaling tool (such as izoom on SGI hardware) to down-sample the images to the desired video resolution. This down-sampling averages several pixels to yield one output pixel, effectively preserving much of the resolution contained in the original full screen image.

Annotation

The smallest annotation text that can be clearly read on video has a font size of 40. For title sequences, use a size of about 65.

If you display parts colored by variables, you should always include the applicable color legend so viewers understand what the coloration represents. For color legends, it is often sufficient to display just one value at the top (the maximum) and one at the bottom (the minimum) in addition to the name of the variable. In fact, sometimes just using "High" and "Low" are sufficient if only the relative magnitudes of the variable are important.

Screen Space

The region of a video display that is "safe" for viewing is typically smaller than your animation display window. You should plan your scenes such that objects of interest (especially annotation entities) do not come "too close" to the edge. If you keep these objects within the range (in EnSight viewport coordinates) .06 to .94 for X (width) and .05 to .95 for Y (height) you should be safe.

Introductory Sequence

Your animation should begin with some title slides explaining the problem domain to your viewers. Try not to put too many words on any one slide and display each one for at least four seconds.

Next, before displaying your results, provide a sequence that introduces viewers to your model. This sequence should be long enough and complete enough to orient the average target viewer to your problem. It is difficult to overestimate the need for this sequence. Without it, viewers are often confused and disoriented for the entire animation.

Credits

You should always include proper credits on any animation you produce. Even animations initially intended only for internal consumption often end up shown to broader audiences.

Stretching an Animation

Ten minutes of video requires 18,000 frames. Only after you have created your first animation will you realize that this can represent a logistical nightmare. In many cases, you can reduce the number of generated frames required using each frame multiple times. If you record two video frames for each actual frame you have, in effect, slowed your animation by half since there are only 15 new frames per second. Although 15 frames per second produces less smooth motion than 30, it is still usually acceptable. Further reduction however, say to 10 unique frames per second, produces noticeable jerkiness.

The Recording Process

There are three basic ways to go about recording your animation:

1. The cheapest method (and the one that typically yields the poorest results) is to simply record the animation directly off the workstation. This can be done either by pointing a video camera at the screen or using the built-in video out signal available on some workstations.

   Although this may be suitable for some simple steady-state problems, the resulting video is usually of very poor quality. Note also that the frame refresh rate is dependent on the complexity of your geometry (which can vary throughout the animation) and the speed of your hardware.

2. EnSight can also write each generated frame to a disk file. Given the current state-of-the-art in hardware and software for video production, this is the preferred method. The images can be further manipulated on disk (*e.g.* color de-saturation or pixel averaging) prior to recording. If a problem occurred, missing or bad frames can be regenerated. Tools also exist to convert sequences of image files to popular animation formats such as MPEG and QuickTime.
3. EnSight can directly output popular animation formats, including MPEG, AVI and its own format - EnVideo.

See Also

User Manual: **“Keyframe Animation” on page 77**